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Outer Planet Flagship Missions (Europa and Titan Orbiters)

Parts Program Requirements

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CHANGE LOG

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1. Introduction

This document establishes the baseline Electrical, Electronic and Electromechanical (EEE) Parts Program Requirements (PPR) for the future Outer Planet Flagship Missions, encompassing both the Europa and Titan orbiters.

Jet Propulsion Laboratory (JPL) and Applied Physics laboratory (APL) are full partners in the proposed missions, and both organizations would be responsible for the execution of all aspects of the Parts Program

Note: *Throughout this document, the term "EEE parts" refers to the flight parts intended for use in flight hardware.*

1.1 Scope

The OPFM parts program will be managed by the Parts Program Manager (PPM) from JPL, and the deputy PPM from APL. This organizational structure is designed to provide a focal point for the parts program related efforts, foster program wide communication on parts issues and facilitate technical teaming. Both, JPL and APL, will have equal responsibilities to implement the requirements of this PPR.

Throughout the project, a teaming approach for the parts program will be employed. Even though the roles and responsibilities remain the same throughout the mission, the emphasis of the roles and the degree of responsibilities might shift as the project progresses with the implementing organization taking on a more prominent role and greater responsibilities for ensuring parts program compliance. Early teaming and effective communication will ensure early identification and mitigation of risks and reduction of redundant efforts.

2. Purpose

The EEE parts program requirements specified herein shall apply to each organization, both internal and external to JPL, supplying EEE parts used in flight hardware. All Flight Hardware contractors, including Payload Instrument providers, are required to submit their Parts Program Implementation Plan to PPM for review and approval.

Every EEE part intended for use in space flight is reviewed and approved for compatibility with the intended space environment and mission life.

Once the PPR has been approved by both the Electronic Parts Engineering Office and Project organizations, deviations from the PPR are documented via a Category B waiver.

3. Technical Requirements

3.1 Applicable Documents

JPL, NASA, Military and other documents of the issue in effect on date of invitation for bids, request for proposal, or product manufacture, form a part of this document to the extent specified herein and are found in the Document Details section (ref Appendix B). In case of conflict, this document shall take precedence.

3.2 Mission Requirements and Environments

3.2.1 The parts requirements are driven by the mission life requirements and the thermal and radiation requirements specified in the Project Environmental Requirements Document (ERD). All parts requirements shall satisfy the mission environmental requirements as specified in the Project ERD.

3.3 Approved Parts and Materials List (APML)

The proposed Europa and Titan projects will develop and maintain an Approved Parts and Materials List (APML) for the purpose of identifying standard parts approved for flight equipment developed under the project's cognizance. Every approved part listed on the APML shall meet the applicable reliability, quality, and radiation requirements (see Section 3.4.4). Due to the higher levels of total dose radiation expected at Europa, the APML will specify the acceptability of parts at 4 radiation levels, 3 pertaining to the proposed Europa mission (100, 300, and 1000Krads) and 1 pertaining for the proposed Titan mission (50Krads).

All parts on the APML will be approved by the Parts Control Board (PCB). The PCB is co-chaired by the JPL and APL PPMs, and is composed of representatives from both organizations of Electronic Parts Engineering, Reliability Engineering Office, design organizations. The PCB recommends and approves parts for inclusion in the APML based on absolute need, the number of subsystems requiring the part, qualification status, Total Ionizing Dose (TID), Single Event Effects (SEE), and procurement specification review.

3.3.1 The APML shall contain approved parts and candidate parts. The candidate part is a device which has been requested by the project as a baseline part, but which has not yet met all requirements of a standard part. Before a candidate part can be listed on the APML, a project Non-Standard Part Approval Request (NSPAR) shall be submitted and approved by the PCB. Upon successful screening and qualification of the part, the part will be added to the APML as an approved part.

3.4 Parts Selection and Standardization

3.4.1 Standard Parts

Standard parts are defined as parts listed on the APML. Designers should use standard parts to the maximum extent possible.

3.4.2 Non-Standard Parts

All parts not listed as approved on the APML are defined as non-standard parts and shall require a NSPAR. All non-standard parts shall be screened and qualified to the requirements of Table 1a or Table 1b. EEE-INST-002 may also be used as a guideline for up-screening and qualification. Requirements should be included in the NSPAR package**.**

3.4.3 Non-standard Part Approval Request (NSPAR) Process

The NSPAR form has five parts (see Section 6.2). The designer initiates a NSPAR by filling in Parts I, II, and III and submitting it to PCB for approval in order to proceed with preparation of the part specification necessary for the procurement, screening, and qualification of the nonstandard part.

Part IV when approved, authorizes the procuring activity to procure and test the parts in accordance with the approved specification. No parts should be procured for flight application without PCB approval.

Part V when approved, affirms that part screening and qualification were performed, that all the requirements were met, and that the part is acceptable for flight.

Note: If part specifications are prepared by the parts specialist, Part IV of the NSPAR shall be completed and approved by the specialist. Specifications prepared by a subsystems contractor shall be submitted with a completed Part IV of the NSPAR to PCB for review and approval.

3.4.4 Part Reliability Requirements

Parts used for the flight systems and payload instruments that are designated as mission critical as defined in the Project Implementation Plan shall meet or exceed the reliability standards shown in Table 1a. Parts used for the subsystems/payload that are not designated as mission critical shall meet or exceed the reliability standards shown in Table 1b. All parts also need to meet the radiation requirements of sections 3.12 through 3.22

Table1a. Parts Reliability Level for Mission Critical Flight Systems and Instruments

	Parts Reliability Standard	Additional Test Requirements
1)	Approved Parts & Materials List (APML)	None
2)	MIL-PRF-38534 Class K level, QML Source	None
3)	MIL-PRF-38535 Class V level, QML Source	None
4)	MIL-PRF-19500 JANS level, QML Source	None
5)	ESA/SCC level B	None
6)	Military Established Reliability (ER) passive devices, Failure Rate T, S, or Weibull failure rate C and D	DPA per 3.8 Surge current testing per 3.10
7)	All other devices not covered above- NASA GSFC EEE-INST-002, devices listed as “use as is” Level 1	None

Table1b. Parts Reliability Level for Non-Mission Critical Flight Systems and Instruments

	Parts Reliability Standard	Additional Test Requirements
1)	Approved Parts & Materials List (APML)	None
2)	MIL-PRF-38534 Class K level, QML Source	None
3)	MIL-PRF-38535 Class V level, QML Source	None
4)	MIL-PRF-19500 JANS level, QML Source	None
5)	MIL-PRF-38534 Class H level, QML Source	Xray, PIND, and DPA
6)	MIL-PRF-38535 Class Q level, QML Source	Xray, PIND, and DPA
7)	MIL-PRF-19500 JANTXV level, QML Source	Xray, PIND, and DPA
8)	MIL-M-38510 Class B level, QPL Source	Xray, PIND, and DPA
9)	Military Established Reliability (ER) passive devices, Failure Rate S and R or Weibull Failure rate C and D.	DPA per 3.8 Surge current testing per 3.10

10)	All other devices not covered above-NASA GSFC EEE-INST-002, Level 2	As defined in EEE-INST-002
11)	ESA/SCC level C	Xray, PIND, and DPA

3.5 Application Specific Integrated Circuit (ASIC) Requirements

Screening and qualification testing shall be in accordance with MIL-PRF-38535, QML level-V requirements.

3.5.1 Digital ASIC Test Requirements

3.5.1.1 Digital logic circuitry in ASICs (including microprocessor, microcontroller and all custom designs) shall be tested to at least 95% stuck-at fault coverage as is defined by MIL-STD-883, Method 5012.

3.5.1.2 In addition, each major functional element of the design shall be tested to at least 90% stuck-at fault coverage.

3.5.1.3 Quiescent current (all vector Iddq method) tests shall be based on a set of vectors that will toggle 95% of the nodes.

3.5.1.4 In addition, each major functional element of the design shall be tested to at least 90% node toggle coverage.

3.5.1.5 Additional tests shall be conducted at room temperature and at maximum rated (hot and cold) temperature that include:

1) Operating speed (or maximum testable speed) functional test to verify all functions of the design and,

2) DC and AC parametric test vectors in compliance with the ASIC specification.

3.5.2 Mixed-signal ASIC Test Requirements

3.5.2.1 For Mixed-signal ASICs with large monolithic digital elements that amount to more than 10% of the design and more than 500 gates, these digital elements shall meet the requirements in paragraph 3.5.1.

3.5.2.2 For Mixed-signal ASICs which are predominantly analog circuits with intermingled flip-flops, registers and counters that amount to less than 10% of the overall design complexity and less than 500 gates, these intermingled digital elements are exempt from the requirements in paragraph 3.5.1.

3.5.2.3 Analog, digital, and mixed signal ASICs shall be modeled or simulated and compared with test data.

3.5.2.4 Additional tests shall be conducted at room temperature and at maximum rated (hot and cold) temperature that include:

1) Operating speed (or maximum testable speed) functional test to verify all functions of the design and,
2) DC and AC parametric test vectors in compliance with the ASIC specification.

3.6 Custom Hybrid, MCM and HDI Microcircuits

3.6.1 Custom hybrid devices designed and fabricated by non-QML sources shall be in conformance with requirements of Class K reliability level of MIL-PRF-38534.

3.6.1.1 Custom hybrid QML sources shall be in conformance with Class H reliability level of MIL-PRF-38534 with a recommended additional 10-piece Class K element evaluation for each device type.

3.6.1.2 Pre-cap visual inspection and document review (e.g. element evaluation, burn-in data and rework travelers) prior to seal shall be required for all hybrids.

3.6.2 To ensure high yields in small lot production runs, all substrates for use in custom hybrids or MCMs, shall be subjected to MIL-PRF-38534 substrate element evaluation.

Note: *The Hybrid Parts Specialist will identify in-process inspection points commensurate with Project requirements and will be called out in the travelers and inspected by Quality Assurance (QA).*

3.7 Field Programmable Gate Array (FPGA) Requirements

Note: FPGAs are not currently acceptable for any applications for Europa Orbiter Mission (spacecraft).

3.7.1 For "one time" programmable devices (e.g., PROMs and FPGAs) any device that fails to program correctly on the first attempt shall be rejected without exception.

3.7.2 FPGA selection and requirements shall be per FPGA design guidelines JPL D-TBD

3.8 Destructive Physical Analysis (DPA) and Residual Gas Analysis (RGA)

3.8.1 When required DPA (and RGA) shall be performed per MIL-STD-1580, or Project approved equivalent document, on each manufacturing lot date code.

3.8.2 RGA applies only to hermetic devices with package volumes equal to or greater than 0.01cc. Resistors and capacitors with R failure rate (as defined in Mil-Specs cited in 3.4.1) or better do not require DPA.

3.8.3 Multilayer ceramic capacitors which are used in less than 10V applications shall be subjected to DPA per the criteria of MIL-STD-1580, except for MIL-PRF-20, MIL-PRF-123, MIL-PRF-39014, MIL-PRF-49470, and MIL-PRF-55681 capacitors.

3.9 Particle Impact Noise Detection (PIND)

3.9.1 When required, PIND shall be performed in accordance with MIL-STD-883, Method 2020, Condition "A."

Note: *Parts being PIND tested will be subjected to one pass only. Rejects will be removed from the lot and the remainder of the parts will be considered to be acceptable.*

3.10 Solid Tantalum Style Capacitor Additional Screening

3.10.1 All solid tantalum capacitors shall be subjected to 100% surge current testing.

3.10.2 The CWR type capacitors shall be tested in accordance with test option B of MIL-PRF-55365.

3.10.3 CSS type capacitors shall be tested in accordance with the appropriate slash sheet of MIL-C-39003.

3.11 Tin-Plated Materials

3.11.1 Tin plate materials with less than 3% lead shall not be used. All commercial parts, or parts recommended by PCB, having tin plated materials shall be shown by Energy Dispersive X-ray (EDX) testing that they contain more than 3% lead. The testing shall be conducted on a sample from each lot and the sample size shall be determined by parts specialist. (For other prohibited materials Reference Material and Processes Control Plan TBD).

3.12 Radiation Requirements

3.12.1 All parts, including hybrid elements, shall be evaluated, by test or analysis, for TID, DD and SEE sensitivity, relative to the radiation requirements as defined in the ERD.

3.12.2 When radiation data is not available, all candidate radiation-sensitive parts shall undergo characterization testing and/or lot acceptance testing, or be shown by analysis to meet the application radiation levels. The effects of TID and DD are not independent, and should be added together for Worst Case Analysis purposes. The combined synergistic effects of TID and DD shall meet the Radiation Design Factor (RDF) requirements defined in the ERD.

3.12.3 Radiation data used in support of candidate device selection shall be submitted to the radiation specialist for review.

3.12.4 Test plans and specifications, including pass/fail criteria, shall be submitted to the radiation specialist to review and approve.

3.12.5 All radiation test and analysis results shall be submitted to the radiation specialist to review and approve.

3.13 Total Ionizing Dose (TID)

All flight parts shall operate within post-irradiation specification limits following exposure to the expected total dose environment (including the RDF) specified in the Europa and Titan orbiter ERD.

Radiation testing shall be performed on all parts which are used in an application where the expected environment is more than the manufacturer's guaranteed radiation tolerance level for the part. Testing shall be performed beyond the expected total dose environment to verify that no catastrophic failure modes are present near the required-radiation level. Where practical radiation characterization testing should extend to 3.0 times the required radiation level or to device failure, whichever occurs first. The TID radiation environment includes gamma rays, protons, electrons, neutrons and heavy ions.

3.14 Enhanced Low Dose Rate Sensitivity (ELDRS)

All linear bipolar and BiCMOS ICs shall be evaluated for susceptibility to ELDRS. When testing is required to determine device susceptibility (e.g., when no applicable radiation data exists), tests shall be in accordance with MIL-STD-883, Method 1019, or as approved by JPL, and additionally as follows: Four groups of samples, comprised of a minimum of five device each, shall be irradiated each in one of four test conditions: high dose rate biased, high dose rate unbiased, low dose rate biased, and low dose rate unbiased. Irradiation dose rate for the high dose rate groups will be between 50 and 300 rad(Si)/s. Irradiation dose rate for the low dose rate groups shall be 0.01 ± 0.002 rad/s for the first 30 krad(Si), or as required by radiation specialist, and 0.040 ± 0.010 rad(Si)/s to the required cumulative dose.

Note: *The criterion for ELDRs sensitivity is a comparison of radiation test samples tested at high dose rate with the results for the samples tested at low dose rate at 30 krad(Si). If the mean value of the samples tested at low dose rate is more than 25% higher than the mean value of the samples tested at high dose rate the part will be designated ELDRs sensitive, requiring RLAT testing at low dose rate.*

3.15 Displacement Damage (DD)

All devices shall be evaluated for susceptibility to DD with analysis or testing. All devices shall operate within post-irradiation specification limits following exposure to the required environment defined in the Europa and Titan orbiter ERD, including the RDF.

Potentially susceptible parts include, but are not limited to, optical emitters, photo-detectors, charge-coupled devices, optocouplers, devices with bipolar elements, and bipolar linear devices. Displacement damage effects shall be added to TID damage for components that are potentially affected by DD.

Note: *The recommended approach is to irradiate devices to the final DD level before the TID tests are done. Alternative ways of dealing with combining DD and TID effects in testing are discussed in the Guideline document # TBD for total dose and displacement damage. A radiation specialist must approve the way that displacement damage and TID effects are dealt with in combined test environments.*

3.16 Radiation Lot Acceptance Testing (RLAT)

All flight lots of active device types shall be subjected to RLAT unless their radiation hardness is established by the manufacturer. Use of existing radiation test data in lieu of RLAT may be approved by radiation specialist. Radiation testing shall be performed in accordance with MIL-STD-883, Method 1019 and Method 1017 or JPL approved equivalent with the exception that RLAT for devices susceptible to ELDRS shall be performed in the worst case condition as determined by characterization testing in accordance with 3.14.

The analysis method for each test condition requires 5 samples, recommend 10 samples, for parts that are not affected by ELDRs, and 40 parts for bipolar devices that are potentially sensitive to the ELDRs effect. Use of smaller sample sizes shall require approval from the radiation specialist.

3.17 Single Event Upset (SEU)

All microcircuits containing bistable elements (e.g., flip-flops, counters, random access memories (RAMs), microprocessors, etc.) shall be characterized so that an upset rate calculation can be performed. A minimum of five different LET values shall be used for characterization. Parts shall be tested to a fluence of 10^7 ions/cm², or until 100 events have been recorded, whichever occurs first. ASTM-1192 and EIA/JESD57 may be used as a test protocol for SEU. The beam angle will not exceed 60 degrees and test ions will have an effective range greater than 50 microns.

Note: *The usual method is to test each device at a sequence of LET values, which will result in a total fluence that is >5 x 10^7 ions/cm^2 when five different LET values are used. Because of concerns about radiation damage, a minimum of two devices that have not been tested at any previous LET value should be tested at the maximum LET value in the test sequence. The results for those two "fresh" devices shall be compared with the test results for other devices in the test sequence in order to determine whether damage during testing affects the results.*

The requirements for parts SEU acceptability are:

- No upsets observed during SEU testing to an LET of 75 MeV-cm^2/mg.
- Verification of bit error rate of < 10^{-10} per day in the galactic cosmic ray environment. In addition, the total number of devices used in the circuit or subsystem must be determined in order to verify that the error rate is low enough to meet overall system requirements.

Single event effects analysis shall verify that system performance requirements are met for all environments including the increase in the radiation environment during a solar flare.

Note: *The high ionizing radiation environment required for the proposed Europa and Titan orbitesr could potentially affect the SEU response because the internal operating conditions of a circuit could change during the course of the mission. In some cases it may be necessary to subject devices that have been irradiated to the required total dose and/or displacement damage levels to SEU testing. A Radiation Specialist must make that determination for specific parts used on the proposed Europa and Titan orbiter, and modify the test plan accordingly.*

3.17.1 Multiple-Bit Upset from Single Ions (MBU)

All microcircuits containing bistable elements must be evaluated for multiple bit upset (MBU). The MBU upset rate must be provided for all parts that contain more than 1,000 internal storage elements. The effects of MBU must be accounted for when SEE analysis is done to verify that circuits and subsystems meet the overall system performance requirements.

3.17.2 Single-Event Induced Stuck Bits

All devices with more than 1000 internal storage elements shall be evaluated for stuck bits up to a maximum LET of 75 MeV-cm^2/mg, using a fluence of 10^7 ions/cm^2. The stuck bit error rate shall be reported for each device.

3.18 Single-Event Functional Interrupt (SEFI)

All CMOS devices shall be subject to SEFI evaluation, using the same test requirements for fluence and ion range required for SEU.

Note*: The cross section for SEFI is reported at the device level, not "per bit" as for other SEU-related effects. From the standpoint of device functionality, many different SEFI categories can occur. The test results must show how various SEFI phenomena affect device functionality, as well as what specific steps are required to (1) identify that a SEFI event has taken place, and (2) to return the device to a normal operating condition. The SEU analysis of a circuit using a device that exhibits SEFI effects must demonstrate that it will function satisfactorily in the galactic cosmic ray environment as well as in the enhanced environment during a solar flare.*

3.19 Single Event Transient (SET)

Single Event Transients (SET) occurs in both analog and mixed signal microcircuits due to protons and heavy ions. All microcircuit applications shall be evaluated to determine how single-event transients will affect the circuit and system functionality. Parts for which an SET would unacceptably impact system operation, shall be evaluated for SET by radiation testing or analysis. Special attention should be given to analog and mixed-signal parts (including voltage regulators) when an initial analysis of SET effects is done.

The electrical conditions for SET tests must overlap the circuit conditions in the application. This includes power supply voltages, input voltages, and output loading.

The requirements for parts SET acceptability are:

1) No transient pulse shall be observed with an amplitude more than 5% of the output voltage, up to an LET of 75 MeV-cm^2/mg, or

2) Single event effects analysis shall verify that system performance requirements are met.

3.20 Single Event Latchup (SEL)

All CMOS and BiCMOS devices, including those with epitaxial layers on heavily doped substrates, shall be subject to latchup evaluation. Testing is generally required, except for parts from radiation hardened lines where the manufacturer has designed the part to be immune to latchup, along with verification by testing. Parts shall be tested to a fluence of 10^7 ions/cm^2. The beam angle will not exceed 60 degrees and test ions must have an effective range greater than 50 microns. The bias shall be at specified maximum voltage. Latchup is strongly temperature sensitive. Tests shall be performed at 25°C and at 90 ºC, or the maximum application temperature of the part if it exceeds 90 º C.

The use of parts that exhibit latchup in the on the proposed Europa and Titan orbiters is strongly discouraged. The basic requirement for parts SEL susceptibility is:

- No latchup to an LET of 90 MeV-cm^2/mg.
- Verification that the device latchup probability in the mission environment is < 10^{-4} per device year for parts that exhibit latchup between 35 MeV-cm^2/mg and 90 MeV-cm^2/mg.

The use of parts with latchup threshold < 35 MeV-cm2/mg are not recommended because of the difficulty of assessing the degraded reliability of parts that have been triggered into latchup, as well as lot-to-lot variability in latchup characteristics.

The test plan for latchup must take into account the effects of damage during testing, and then additional testing is required to verify this. Latchup tests shall be done with an LET of 90 MeV-cm^2/mg on at least two fresh devices that have not been previously irradiated at lower LET values to verify that the cumulative effects of damage during testing do not affect the results.

Note*: When the use of latchup sensitive parts is necessary, SEL testing of the specific lots used is required, using results from the highest test temperature. The tests must verify that the device latchup probability in the mission environment is < 10^{-4} /device-year for parts that exhibit latchup between 35 MeV-* cm^2*/mg and 90 MeV-* cm^2*/mg. In addition, the total number of components must be taken into account to show that the total impact of latchup events is consistent with overall mission requirements.*

3.21 Single Event Gate Rupture (SEGR)

All power MOSFETs shall be evaluated for single event gate rupture (SEGR) at the worst-case application V_{GS} and V_{DS} values. The survival voltage (V_{DS}) shall be established from exposure to a minimum fluence of 10^6 ions/cm² of an ion with a minimum LET of 32 MeV-cm^2/mg. The range depends on the device voltage rating as shown in the Table 2 below. Testing shall be performed on 5 samples at an LET of 32 MeV-cm^2/mg with normal beam incidence at room ambient temperature. The application voltage shall be derated to 75% of the established survival voltage, determined from radiation test data. Tests are usually done using successive steps in drain-source and gate-source voltage. The survival voltage is the highest voltage where no SEGR occurs, not the voltage that corresponds to the onset of the first failure.

Table 2. Ion Range as a Function of Rated V_{DS} for MOSFETs.

Maximum Rated Drain-Source Voltage	Minimum Ion Range (microns) At Depletion Region
< 100	30
100 to 250	40
251 to 400	80
401 to 1000	200

3.22 Single Event Burnout (SEB)

All power transistors operated in the off-mode shall be evaluated for single event burnout (SEB) at the worst-case application V_{CE} (for bipolar devices) or V_{DS} (for MOS devices). The survival voltage (V_{CE} or V_{DS}) shall be established from exposure to a minimum fluence of 10^6 ions/cm² of an ion with a minimum LET of 32 MeV-cm^2/mg and with a range depends on the voltage rating of the device. The previous table for SEGR tests of power MOSFETs is applicable to SEB for both power MOSFETs and bipolar transistors (replacing V_{DS} with $V_{CE.}$ Testing shall be performed with normal beam incidence at room ambient temperature. Test requirements for single event burnout are similar to those for SEGR except that the drain current (or collector current for a bipolar transistor) must be measured to determine if burnout occurs. The application voltage shall be derated to 75% of the established survival voltage, determined from the lowest “pass” voltage from radiation test data. 5 samples are required for SEGR.

4. Implementation Requirements

4.1 Management Requirements

4.1.1 All EEE parts used on the project shall be selected from the APML and shall be reviewed by parts engineering. The review results shall be documented in the Parts Review Database (PRDB).

4.2 Parts Control Board (PCB)

The PCB recommends and approves parts for inclusion in the APML based on absolute need, the number of subsystems requiring the part, qualification status, TID, SEE, and procurement specification review. All proposed parts that are not listed on APML shall be submitted through a NSPAR to PCB for review and approval. Approval/disapproval of parts completing the evaluation process by the PCB will be documented in the meeting minutes. Additionally, all final as-built parts list shall also be approved by PCB

4.3 Parts Program Manager

The PPM and deputy PPM has the responsibility to successfully implement the parts program requirements. Reporting relationships within each organization will be in accordance with the practices and procedures of each organization. The roles and responsibilities of the PPM will include, but are not limited to, the following;

- Manage PCB activities and maintain APML.
- Preparation and maintenance of the Project Parts Program Requirements
- Ensure that the parts program is implemented within the scope, budget, and schedule, as defined in this plan and agreed upon by the Project and Mission Assurance organizations
- Ensure compliance of all contractor parts program plans.
- Reports parts program status to JPL and APL line management and project during monthly MMRs.
- Reports and manages risks within the parts program.

4.4 Monthly Reviews

4.4.1 The PPMs (JPL and APL) shall provide a joint monthly management review (MMR) to the project and the line managers of the Electronics Parts Engineering office The MMR presentation will include, but is not limited to, the following topics:

- Progress and status of parts lists reviews, parts procurement, NSPARs, waivers, lessons learned, GIDEP Alerts and resolution
- Accomplishments
- Budget status
- Workforce status
- Issues and concerns (budget, workforce, part procurement), particularly those that would prevent the accomplishment of next month’s or future tasks

Action items will be documented, tracked and reported as part of the monthly status.

4.5 Waivers

4.5.1 Category B waivers are required for all parts not meeting the requirements of this document. JPL internal procedure will be used for Category B waivers against the PPR.

4.6 Application Specific Integrated Circuit (ASIC)

4.6.1 The parts specialist shall be a member of the design team and attend ASIC Design team meetings.

Note: *ASIC design guidelines to monitor the design and test vector generation will be documented and reviewed by the ASIC Parts Specialist.*

4.6.2 All ASIC developments for the project shall have Preliminary Design Reviews (PDRs), Critical Design Reviews (CDRs), Manufacturing Readiness Review (MRRs), and Monthly Management Reviews (MMRs) to monitor technical, budget, and schedule progress. Special The Parts Interface Engineer and Parts Specialists will participate in all reviews.

Note: *The design reviews will address as a minimum, derating requirements, parts screening and qualification, radiation effects evaluation, verification of controlled engineering materials, processes, thermal and other design analysis as applicable to mission requirements.*

4.7 Custom Hybrid, MCM, HDI Microcircuits, and Complex Radio Frequency (RF) Parts

4.7.1 The parts specialist shall be a member of the design team and attend Hybrid Design team meetings to monitor the design and test methodology.

4.7.2 All projects requiring hybrid microcircuits shall have PDRs, CDRs, Manufacturing Readiness Review, Peer Reviews and MMRs

Note: *The design reviews will address, as a minimum; derating requirements, element evaluation and quality levels, radiation effects evaluation, verification and control of materials, processes, thermal and other design analysis as applicable to mission requirements.*

4.8 Programmable Devices

4.8.1 All FPGA developments for the project shall have Preliminary Design Reviews (PDRs), Critical Design Reviews (CDRs), Manufacturing Readiness Review (MRRs), and Monthly Management Reviews (MMRs) to monitor technical, budget, and schedule progress. The Parts Interface Engineer and Parts Specialists will participate in all reviews.

4.8.2 The parts specialist shall review all test fixtures, test board schematics, specifications and procedures prior to programming or test performance

4.9 Parts List Review

The parts engineering shall review the Parts List for risk assessment and document the results in the PRDB. The submittal of the preliminary as-designed list shall be at least 30 days prior to PDR to the PPM. A final “As-designed” list shall be submitted at a minimum of 30 days prior to CDR of each System Element. All additions or modifications will be highlighted and submitted within one month of the change. The parts lists should include:

1. *part number*
2. *value/tolerance/rating*
3. *part specification/source control drawing number*
4. *generic part number*
5. *part description (e.g., ceramic capacitor, or quad nor gate)*
6. *proposed part manufacturer*
7. *the review and approval status for nonstandard parts*
8. *the review and approval status of any waivers*
9. *an estimate of the quantities to be used*
10. *application usage notes that can aide the specialist in reviewing parts*

4.10 As-Built Parts List

4.10.1 The parts engineering shall review the As-Built Parts List for risk assessment prior to hardware delivery (HRCR).

Note: *In addition to the information required in the parts lists, the as-built parts list should include for each different part the following:*

1. *actual part marking*
2. *part number*
3. *manufacturer*
4. *lot date code*
5. *serial number (for serialized parts)*
6. *procurement specification number*

The final As-built parts list will be approved by PCB

4.11 Parts Acquisition

4.11.1 Parts Procurement

4.11.1.1 Parts for flight equipment shall be procured directly from the approved part manufacturers or authorized distributor when traceability to the manufacturer can be established.

4.11.1.2 Purchase orders and/or purchase requisitions shall not contain exceptions to referenced specifications or requirements unless approved via the NSPAR.

4.11.2 Traceability

4.11.2.1 All flight parts purchased shall be traceable to a specific manufacturer, part number, and lot number or lot date code. In addition, parts requiring serial numbers will have traceability to test data associated with the same lot.

4.11.3 Parts Data Requirements and Data Retention

4.11.3.1 The manufacturer's or vendor's certificate of conformance for each electronic part lot shall be obtained by the procuring activity and retained for a period of launch plus three years or as directed by the Project.

Note: *The parametric data will be traceable to each serialized part. All variables and attributes data generated in compliance with the specification will be delivered to the procuring activity.*

4.11.3.2 The data shall be reviewed by the procuring activity for technical acceptability and completeness. The read and record data may be required when the project needs to establish worst-case circuit analysis parametric data points.

Note: *This will be included in the parts procurement as requested by the project. All test and evaluation data will be submitted to the PPM for review (electronic format is preferred).*

4.11.4 Customer Source Inspection (CSI)

4.11.4.1 Pre-seal visual inspection shall be performed on all packaged flight ASICs, hybrid microcircuits, MCMs, crystal oscillators, and relays by the procuring agency.

4.11.5 Quality Assurance (JPL only)

4.11.5.1 All incoming flight piece parts shall be inspected by Quality Assurance Office (QA) prior to final storage in Flight Stores.

4.11.5.2 All piece parts requiring upgrades, screenings or testing shall be inspected by QA upon their return to Flight Stores.

4.12 Electronic Parts Application and Derating

4.12.1 Parts Derating

4.12.1.1 Each part used in flight equipment shall be applied in a manner such that the temperatures experienced and electrical stresses produced when it is operating do not exceed the derating criteria defined in JPL Derating (D-8545), or JPL approved equivalent.

4.12.1.2 Each part used in flight equipment shall be applied in a manner such that the parametric circuit tolerances are met while using the worst case parameter design data defined in the Approved Part and Material List.

4.12.2 Handling / Storage / Electrostatic Discharge (ESD) Control Requirements

4.12.2.1 Parts shall be protected from ESD during incoming inspection, testing, screening, storing and final assembly/test. To protect static-sensitive parts from ESD, handling of parts shall be controlled by the requirements of JPL Electrostatic Discharge (ESD) Control (D-1348), or JPL approved equivalent.

4.12.3 NASA Advisories and Government Industry Data Exchange Program (GIDEP) Alerts

4.12.3.1 All hardware-delivering design agencies, both internal and external to JPL, shall assure the implementation of a system to review NASA Advisories and GIDEP Alerts, take appropriate action, and notify their respective Alert coordinators of significant parts problems that may warrant issuance of new Alerts.

4.12.3.2 Projects shall continue to review their parts list against GIDEP Alerts and NASA Advisories issued through launch plus 30 days, except that Earth fly-by and Earth return projects continue their review through final Earth fly-by or sample return

Note: *Design agencies which do not presently receive Alerts directly should request distribution from the Defense Supply Center Columbus (DSCC), GIDEP Operations Center or the JPL Alert Coordinator. The design agency is responsible for reviewing all Alerts, and for immediately reporting corrective action for applicable Alerts (i.e. for parts used in the hardware) to the project and appropriate Alert Coordinator.*

4.12.3.3 The design agency shall present a review matrix of all Advisories and Alerts at the CDR, and at the Pre-Ship Review, that lists all of the Alerts which are pertinent to the parts used in the flight design, the possible impact should the part fail, and the actions proposed and those taken. It is the responsibility of the design agency to avoid the use of defective parts in flight equipment.

4.12.4 Failure Analysis

4.12.4.1 Failure analysis shall be performed for all part failures that occur during life test (for custom devices and parts that require upscreening) or subsequent to first application of power after installation. The PPM will be notified in writing within 3 days of any failure occurrence. The only exceptions are parts damaged by human error (e.g., improper installation).

4.12.4.2 Analysis shall be carried to the point that lot dependency of the failure mode can be determined Failure analysis reports will be written to document the analysis approach, the determined failure mode and mechanism (i.e., cause) responsible for the failure, and the corrective actions required to prevent recurrence of the failure. If a lot dependency is found, the PCB will disposition the parts.

5. Contractors

5.1 JPL Subcontractors and Partners or any other design agency external to JPL which furnishes flight equipment shall be subjected to all requirements of this document unless stated otherwise.

5.2 Each organization utilizing a contractor shall contractually require the contractor to establish an electronic parts program consistent with the requirements of this PPR.

5.3 All subcontractors and Partners shall submit to the PPM, for review and approval, an implementation plan addressing how they will meet the technical requirements of this document. The plan should also include the supplier's schedule and shall be approved by the PPM prior to the supplier initiating their parts program. Each supplier and their management shall assure that the necessary support is allocated for the implementation of their parts program plan.

5.3.1 The implementation plan shall also address how these requirements will be flowed down to sub-tier contractors.

5.4 The contractors shall submit to the PPM for review and approval: parts lists, part specifications, and radiation lot acceptance test plans.

5.5 All contractor parts lists shall be reviewed and risk rated by the PPM 30 days prior to PDR, CDR, and HRCR.

5.6 All contractors shall be responsible for the performance of failure analysis on parts that the contractor procures in accordance with the failure analysis requirements herein. Failure analysis results will be made available to the PPM for review.

6. Appendices

6.1 Acronym List

The following is a list of the acronyms and their meanings used in this document:

Acronym	Meaning
APML	Approved Parts and Materials List
ASIC	Application Specific Integrated Circuit
COTS	Commercial Off-the-Shelf
CSI	Customer Source Inspection
	DD Displacement Damage Dose
DPA	Destructive Physical Analysis
DSCC	Defense Supply Center Corporation
ESD	Electrostatic Discharge
EEE	Electrical, Electronic, and Electromechanical
ELDRS	Extreme Low Dose Rate Susceptibility

FPGA	Field Programmable Gate Arrays
GIDEP	Government Industry Data Exchange Program
HDI	High Density Interconnect
HRCR	Hardware Review Certification Record
IR	Inspection Report
LET	Linear Energy Transfer
MCM	Multi-Chip Module
MeV	Mega (Million) Electron Volts
MMR	Monthly Management Review
MRB	Material Review Board
NSPAR	Non-Standard Parts Approval Request
PCB	Parts Control Board
PEM	Plastic Encapsulated Microcircuits
PIND	Particle Impact Noise Detection testing
PPR	Parts Program Requirements
PRDB	Parts Review Database
PROM	Programmable Read Only Memories
QA	Quality Assurance
RDF	Radiation Design Factor
RGA	Residual Gas Analysis
RLAT	Radiation Lot Acceptance Test
SCD	Source Control Document
SEB	Single Event Burnout
SEE	Single Event Effect
SEFI	Single Event Functional Interrupt
SEGR	Single Event Gate Rupture
SEL	Single Event Latch-up
SET	Single Event Transient
SEU	Single Event Upset
TID	Total Ionizing Dose

6.2 Appendix A NSPAR Form

NONSTANDARD PART APPROVAL REQUEST
(NSPAR)

I	1 PROJECT			2 DATE SUBMITTED
	3 CONTRACTOR	4 CONTRACT NUMBER:		5 NSPAR NO Rev
	6 SUBCONTRACTOR	7 SUBCONTRACT NUMBER:		8 JPL/NASA LOG NO Rev
	9 SYSTEM / SUBSYSTEM / ASSEMBLY/LIST ("WHERE USED")			
II	10 TID REQUIREMENT	11 SEU REQUIREMENT	12 LATCHUP REQUIREMENT	13 PART GRADE:
III	14 PART DESCRIPTION			
	15 MANUFACTURER PROCUREMENT NO		16 GENERIC PART NO	
	17 MANUFACTURER(S)			
	18 PROCUREMENT SPEC			REV
	19 SCREENING SPEC			REV
	20 RADIATION TEST SPEC			REV
	21 CLOSEST STANDARD PART			
	22 TECHNICAL RATIONAL FOR NOT USING STANDARD PART			
	23 TECHNICAL BASIS FOR ACCEPTANCE			
	(Requesting Activity)	24 PREPARED BY DATE	25 APPROVED BY DATE	
IV	26 JPL PARTS SPECIALIST REVIEW DATE	APPROVED ☐	CONDITIONALLY APPROVED ☐	DISAPPROVED ☐
	COMMENTS/NOTES			
	27 GIDEP ALERT YES ☐ NO ☐	28 GIDEP NUMBER(S):		
	29 JPL RADIATION (TID & SEE) REVIEW DATE	APPROVED ☐	CONDITIONALLY APPROVED ☐	DISAPPROVED ☐
	COMMENTS/NOTES			
V	30a CERTIFICATION OF MEETING NSPAR REQUIREMENTS	TITLE PARTS SPECIALIST	DATE	
	30b CERTIFICATION OF MEETING NSPAR REQUIREMENTS	TITLE RADIATION SPECIALIST	DATE	

INSTRUCTIONS FOR ENTERING DATA ON NONSTANDARD PARTS APPROVAL REQUEST

This NSPAR form is used to request approval of use of a nonstandard part as defined by JPL D-5357

I. Requester fills in:

Block 1 - Enter the Project name.

Block 2 - Enter the date submitted or resubmitted, as applicable.

Block 3 - Enter the name of the system or instrument contractor, as applicable.

Block 4 - Enter the contract number assigned by PCB.

Block 5 - Enter the initiating organization's NSPAR number.

Block 6 - Enter the name of the subcontractor, as applicable.

Block 7 - Enter the subcontract number as assigned by PCB.

Block 8 - Leave this blank. PCB will fill in this Log Number when the NSPAR is submitted.

Block 9 - Enter the name of the system, subsystem and assembly, in which the part is being used. (Example: communication system, wideband transmitter, power supply.)

II. Requestor fills in Requirements and part quality:

Block 10 - Enter the Total Ionizing Dose requirement for this assembly.

Block 11 - Enter the Single Event Upset requirement for this assembly.

Block 12 - Enter the Latchup requirement for this assembly.

Block 13 - Enter the grade of the part in question.

III. Requestor fills in Part specifications:

Block 14 - Enter the part description (example: capacitor, solid tantalum; resistor, wire wound power.)

ONLY ONE PART TYPE PER NSPAR IS PERMITTED.

Block 15 - Enter the part number, which uniquely identifies the part. If it is a nonstandard military part, enter the military part number. If it is procured by to an existing Source Control Drawing (SCD), enter the part number as identified in the SCD. Otherwise, use the commercial designation.

Block 16 - Enter the generic number for the part.

Block 17 - Enter the name and location of the manufacturer of the part or device. Multiple source listings may appear on a single NSPAR form.

Block 18 - Procurement Specification: the spec. to which the part is procured (example: SCD, CS, ST).

Block 21 - Enter the closest standard part.

Block 22 - Enter the technical reason for not using a standard part.

Block 23 - Enter the technical basis for acceptance of a nonstandard part. This basis should include qualification and radiation status, reports, and part grade.

Block 24 - Requester signs and dates.

Block 25 - Requester's approving activity, as applicable, signs and dates here.

IV. JPL Section 514 Fill in:

Block 26 - Parts Specialist approved/conditionally approved/disapproved, signature, date and review Comments.

Block 27 - Parts Specialist enters yes or no for existing GIDEP alerts for part or device.

Block 28 - Parts Specialist will identify GIDEP number(s) applicable.

Block 29 - Radiation approved/conditionally approved/disapproved, signature, date and review comments.

V. Certifying Activity fills in:

Block 30a & 30b - Certification by parts quality assurance activity, certifying that all parts referenced by this NSPAR have been subjected to and meet all the requirements of the specifications listed in Blocks18-20; and, where DPA is required, the results were reviewed by the procuring activity and found acceptable. Quality Assurance certifies that NSPAR Completion after closure of the Parts Pedigree Traveler. Contractor parts quality assurance activity shall certify NSPAR completion as described in its Parts Program Plan.

6.3 Appendix B Applicable Documents

- Guideline: JPL Derating (D-8545)
- Standard: Electrostatic Discharge (ESD) Control (D-1348)

Related documentrs:

- Charter: Parts Program Review Board
- Other: MIL-PRF-19500 General Specification for Semiconductor Devices
- Other: MIL-PRF-38534 General Specification for Hybrid Microcircuits
- Other: MIL-PRF-38535 General Specification for Manufacturing Microcircuits
- Other: MIL-PRF-39003 General Specification for Capacitor, Fixed, Electrolytic (Solid Electrolyte), Tantalum, Established Reliability
- Other: MIL-PRF-55365 General Specification for Capacitor, Fixed, Electrolytic (Tantalum), Chip, Non-established Reliability, Established Reliability
- Other: MIL-STD-883 Test Methods and Procedures for Microelectronics
- Other: NASA GSFC EEE-INST-002 Instructions for EEE Parts Selection, Screening, and Qualification
- Other: QML-38534 Qualified Manufacturers List for Hybrid Microcircuits
- Other: QML-38535 Qualified Manufacturers List of Microcircuits
- Other: QPL-19500 Qualified Products List of Products Qualified under MIL-PRF-19500, General Specification for Semiconductor Devices
- Other: MIL-STD-1580 Destructive Physical Analysis of Electronic, Electromagnetic and Electromechanical Parts
- Procedure: Category A Waiver Request/Approval
  - Procedure: Control of Nonconforming Product (QAP 144.2)